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ABSTRACT

The purpose of this study was to explore the possibility that the relationships between students' aptitudes and achievements differ from teacher to teacher. If this were so, it would suggest that teacher effectiveness can not be described adequately by measures of average class achievement. The report demonstrates the use of univariate and bivariate regression analyses to study differences among teachers. The subjects were teacher trainees and paid volunteer high school students who participated in Stanford's Teacher Education Program (STEP) in the summer of 1967. Data were obtained from the Intern Data Bank, a collection of information about teaching interns at Stanford. The regression analysis approach to this question is demonstrated and discussed; student aptitude-achievement relationships did not vary substantially among the teachers studied, although some individual teachers displayed distinctive patterns. A 10-item bibliography and figures are included. (Author)

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Research and Development Memorandum No. 85

TEACHER DIFFERENCES AS REFLECTED IN STUDENT APTITUDE-ACHIEVEMENT RELATIONSHIPS

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Introductory Statement

The Center is concerned with the shortcomings of teaching in American schools: the ineffectiveness of many American teachers in promoting achievement of higher cognitive objectives, in engaging their students in the tasks of school learning, and, especially, in serving the needs of students from low-income areas. Of equal concern is the inadequacy of American schools as environments fostering the teachers' own motivations, skills, and professionalism.

The Center employs the resources of the behavioral sciences--theoretical and methodological--in seeking and applying knowledge basic to achievement of its objectives. Analysis of the Center's problem area has resulted in three programs: Heuristic Teaching, Teaching Students from Low-Income Areas, and the Environment for Teaching. Drawing primarily upon psychology and sociology, and also upon economics, political science, and anthropology, the Center has formulated integrated programs of research, development, demonstration, and dissemination in these three areas. In the Heuristic Teaching area, the strategy is to develop a model teacher training system integrating components that dependably enhance teaching skill. In the program on Teaching Students from Low-Income Areas, the strategy is to develop materials and procedures for engaging and motivating such students and their teachers. In the program on Environment for Teaching, the strategy is to develop patterns of school organization and teacher evaluation that will help teachers function more professionally, at higher levels of morale and commitment.

The present study is part of the Heuristic Teaching Program. It explores the possibility that teacher effectiveness must be defined using student aptitude-achievement relationships rather than simply average student achievement.

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Abstract

The purpose of this study was to explore the possibility that the relationships between students' aptitudes and achievements differ from teacher to teacher. If this were so, it would suggest that teacher effectiveness cannot be described adequately by measures of average class achievement. The report demonstrates the use of univariate and bivariate regression analyses to study differences among teachers. The subjects were teacher trainees and paid volunteer high school students who participated in Stanford's Teacher Education Program (STEP) in the summer of 1967. Data were obtained from the Intern Data Bank, a collection of information about teaching interns at Stanford. The regression analysis approach to this question is demonstrated and discussed; student aptitude-achievement relationships did not vary substantially among the teachers studied, although some individual teachers displayed distinctive patterns.

TEACHER DIFFERENCES AS REFLECTED IN STUDENT APTITUDE-ACHIEVEMENT RELATIONSHIPS

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The common hypothesis that teacher differences influence classroom interaction and its outcomes is usually stated in noninteractive terms. That is, teacher differences in effectiveness are expressed as differences in overall class performance (mean class achievement or gain, and the like). But teachers often report doing better with one type of student than with another. To borrow Thelen's (1967) terminology, the most teachable student-type varies from teacher to teacher. Only recently have attempts been made to investigate this intriguing possibility--that a given teacher may be more effective with one type of student than with another, and that different teachers may vary with regard to what types of students they are more effective with. The few attempts (e.g., Heil, Powell, & Feifer, 1960; McKeachie, 1961; McKeachie, Lin, Milholland, & Isaacson, 1966; Thelen, 1967) to examine this notion have been hampered by limited methods for describing these teacher differences. This paper discusses one possible method, using the aptitude-treatment interaction (ATI) approach (Cronbach & Snow, 1969). If teachers are considered treatment variables, the general hypothesis may be stated as follows: teachers differ in the aptitude-achievement relationships exhibited by their students. For some teachers, student outcomes (such as achievement and interest) may be highly related to student aptitude (such as ability variables, personality variables) whereas for others, student outcomes may be minimally related to aptitude.

Aptitude-teacher interactions were investigated in this study by means of regression analysis procedures using univariate and multivariate independent (aptitude) variables. Teacher differences are thus described here in terms of the slopes of regression lines and planes. The presence of ATI is tested by means of the F test for homogeneity of regression. Differences in teacher effectiveness as shown by mean class performance are of secondary interest.

The present study was considered a pilot venture to help develop the approach and to identify practical and methodological problems for subsequent research. Limitations on the data available prevent us from drawing substantive conclusions at this time. Data used for these analyses were obtained from a data bank containing information about Stanford teaching interns. A brief description of materials used follows; more complete information is available from the Center's Microteaching and Intern Data Bank Project.

Method

Students. Paid high school student volunteers participated as students for the intern teachers. Although students were randomly assigned to classes of about twenty, the June and August pools of participants came from different school districts and thus differed in unspecified ways.

Teachers. From interns participating in the Stanford Teacher Education Program, 31 teachers specializing in English or Social Studies were selected for the study.

Aptitude Data. Each high school participant was given two aptitude tests measuring verbal and reasoning abilities. In June the Wide Range Vocabulary and Necessary Arithmetic Operations tests were administered; in August, the Advanced Vocabulary and Mathematics Aptitude tests. All tests were chosen from the Educational Testing Service kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963).

Preset Lessons. For each lesson, a topic and body of material appropriate to a high school English or Social Studies class was prescribed. The Social Studies topics used in this study included, for example, "Money Grows Up in America" and "The Bimetallic Standard." The English topics included "Persuasion" and "Symbolism." Interns taught one lesson in June 1967, at the beginning of the teacher-training program, and another (same subject area but different topic) in August 1967, at the end of the microteaching clinic.

Achievement Data. Each topic was accompanied by a 20-item multiple-choice achievement test on the material covered in the lesson. These tests were administered by the teacher immediately after the lesson was presented.

Other Data. Information concerning the teachers' behavior is available from typescripts and videotapes. These data could be related to the aptitude-achievement relationships, but this possibility was not pursued in the present study.

Thus the general procedure, both in June and August, was as follows: (1) student aptitude information was collected; (2) each intern taught the material in his or her own way to a randomly assigned group of paid volunteer students; and (3) achievement information was collected from the students immediately after the lesson.

Since the Intern Data Bank information was not collected with the present study in mind, comparisons of teachers with regard to their effectiveness with students of different aptitudes can be made only on a limited basis. For example, the fact that June and August subjects were drawn from different populations and took different aptitude tests limits the meaningfulness of statements about changes in teacher effectiveness over time and training.

Also, class sizes were too small to provide highly reliable estimates of parameters for regression equations. Despite these limitations, the Data Bank did provide information judged adequate for this pilot, exploratory demonstration of the approach.

The Univariate Aptitude Case

Our basic question was whether different degrees of student aptitude-achievement relationships could be observed across teachers giving a particular lesson. First we considered the two aptitude variables separately by computing, for each class, a regression equation describing the relationship between Social Studies or English achievement and verbal or reasoning aptitude. When the aptitude-achievement relationships are expressed in this form, teacher differences can be represented in terms of the heterogeneity of obtained regression slopes. The hypothesis that these regression slopes are parallel can be tested; its alternative is that the slopes differ, suggesting that teacher variables interact with student aptitude. Regression equations were computed and F tests of departure from parallel slope were performed (see Walker & Lev, 1953, for a detailed discussion of this test).

Two groups of Social Studies teachers were examined by this method. Group 1, consisting of eleven teachers, taught Social Studies Lesson 1 in June and Lesson 5 in August. Group 2, consisting of nine teachers, taught Social Studies Lesson 2 in June and Lesson 6 in August. These groupings are significant only in that the teachers prepared and taught the same preset lessons. Thus for each teacher (with a few exceptions) four regression equations could be computed: verbal aptitude x achievement before and after teacher training (that is, for the June and the August class), and reasoning aptitude x achievement before and after teacher training. These equations, with associated F tests of slope heterogeneity, are presented in Tables 1 and 2. It can be seen that none of these F tests reached significance, using the .05 level.

The results have also been presented graphically in Figures 1 through 8 (see pp. 14-21). Each figure shows the regression lines for each teacher for a given lesson and aptitude. Thus Figure 1 shows the relationship between student verbal aptitude and achievement for each teacher of Social Studies Lesson 1, given in June. Figure 2 shows similar information for the same group of teachers obtained when they taught Social Studies Lesson 5 in August. The length of each regression line indicates the range of scores observed in that class. By superimposing regression lines, one can compare various teachers to see that: (a) the lines cluster without much deviation from parallelism; (b) individual teachers' classes do differ in mean achievement levels and achievement ranges; and (c) some individual teachers do seem to demonstrate aptitude-achievement relationships that differ markedly from the group pattern (albeit nonsignificantly). For instance, contrast Teachers 48 and 155 as shown in Figure 1. Teacher 48 appears to do better with students of high verbal

TABLE 1

Regression Equations and Tests of Homogeneity for
Social Studies Group 1 Teachers

Teacher (identified by number)	Achievement Regression on Verbal Aptitude				Achievement Regression on Reasoning Aptitude			
	June Lesson 1		August Lesson 5		June Lesson 1		August Lesson 5	
	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope
2	3.96	.30X	6.22	.19X	2.29	.52X	6.00	.27X
33	----[a]	----	3.97	.11X	----	----	4.30	.01X
48	1.72	.44X	7.59	.26X	-.92	.71X	9.17	.23X
59	9.23	.19X	----	----	8.51	.27X	----	----
76	----	----	3.79	.22X	----	----	7.75	-.05X
90	----	----	5.85	.05X	----	----	7.09	-.05X
145	4.89	.26X	4.72	.25X	2.45	.48X	6.45	.18X
154	5.05	.27X	10.27	.12X	2.70	.46X	11.60	.07X
155	9.41	-.04X	8.91	-.05X	5.55	.27X	7.61	.06X
156	8.27	.14X	6.87	.28X	2.89	.53X	8.81	.22X
164	----	----	8.61	.00X	----	----	8.03	.06X
All teachers combined	5.67	.25X	6.39	.17X	2.96	.49X	7.76	.11X
	F = 1.39 df = 6,135		F = 1.29 df = 9,205		F = 1.00 df = 6,135		F = .82 df = 9,205	

[a]Dash indicates absence from teaching session.

TABLE 2

Regression Equations and Tests of Homogeneity for
Social Studies Group 2 Teachers

Teacher (identified by number)	Achievement Regression on Verbal Aptitude				Achievement Regression on Reasoning Aptitude			
	June Lesson 2		August Lesson 6		June Lesson 2		August Lesson 6	
	Intercept	Slope	Intercept	Slope	Intercept	Slope	Intercept	Slope
17	5.56	.18X	5.09	.10X	-.05	.59X	5.65	.10X
46	----[a]	----	3.65	.32X	----	----	2.69	.43X
79	6.98	.19X	4.29	.28X	1.56	.57X	4.58	.28X
101	3.17	.13X	5.23	.15X	1.79	.25X	5.31	.20X
105	.80	.18X	6.66	.27X	.74	.24X	5.72	.43X
110	4.37	.10X	4.51	.24X	3.63	.17X	3.70	.41X
111	5.17	.24X	3.66	.23X	3.72	.36X	3.80	.31X
121	3.74	.22X	6.02	.09X	2.91	.31X	3.38	.35X
169	5.50	.13X	3.77	.28X	1.94	.45X	2.58	.53X
All teachers combined	5.40	.11X	4.56	.24X	2.25	.35X	3.83	.37X
	F = .13 df = 7,141		F = .46 df = 8,188		F = 1.33 df = 7,141		F = 1.15 df = 8,188	

[a]Dash indicates absence from teaching session.

ability. Teacher 155, though appearing to produce about the same average results, does almost equally well with students of various levels of verbal ability. The interpretation of such a result is not warranted here, but further research specifically designed for this type of analysis might permit interpretations concerning the consistency of teacher effectiveness across situations or occasions, the effects of training, and so on.

The Bivariate Aptitude Case

The univariate aptitude analysis can be extended to take into account two or more student aptitudes at the same time by means of multiple regression techniques. The basic question of teacher differences with respect to student aptitude-achievement relationships remains the same, though we now examine regression planes (or hyperplanes) for parallelism as evidence of these differences. The advantage of the multiple regression procedure is to unify the description of aptitude-achievement relationships, allowing us to examine a teacher's effectiveness with students having different combinations of aptitudes.

With the same data used in this study, the joint relationship of verbal and reasoning aptitude to achievement was investigated. Program BMD 03R (Dixon, 1967) was used to compute multiple regression equations and to perform tests of heterogeneity of regression planes. This test is analogous to that performed in the univariate case. Multiple regression analyses were performed for the group of teachers presenting Social Studies Lessons 1 and 5 (essentially a reanalysis of the data forming the basis for Table 1 and Figures 1-4). In addition, data from a group of eleven teachers giving English Lesson 3 in June and English Lesson 4 in August were analyzed. Regression coefficients and multiple correlation coefficients from these analyses are presented in Tables 3-6. Tests for heterogeneity of regression coefficients were not computed for any of the groups. However, we can use these results to demonstrate what possible teacher differences in regression planes might look like. Figure 9 (see p. 22), a three-dimensional perspective, shows the student aptitude-achievement relationships for two teachers who were selected as representing extremes for their groups. The vertical axis represents student achievement scores, and the two horizontal axes represent student verbal and reasoning aptitudes. The boundaries of the planes indicate the score limits of the tests rather than the ranges obtained in the present data. Apparently, Teacher 57 did equally well with students of all aptitudes. Teacher 95, in contrast, did very well with students with high verbal and reasoning aptitudes, somewhat better than T57 with Ss with low verbal and high reasoning aptitudes, and not as well with Ss with low reasoning aptitudes or low verbal and reasoning aptitudes. Again, these results are presented only as a demonstration, to give a feeling for possible interpretations in this kind of study.

TABLE 3

Regression Analyses for Seven Social Studies Teachers on Microteaching Pretest Lesson 1, June 1967

Teacher	N Ss	Regression Coefficient		Intercept	Multiple Correlation Coefficient R
		Verbal	Reasoning		
2	23	.21	.41	-.03	.81
48	21	.25	.47	-1.71	.78
59	22	.13	.18	7.48	.52
145	22	.18	.34	1.43	.60
154	23	.14	.34	2.33	.72
155	20	-.03	.27	6.08	.28
156	18	-.03	.55	3.01	.68

TABLE 4

Regression Analyses for Ten Social Studies Teachers on Microteaching Posttest Lesson 5, August 1967

Teacher	N Ss	Regression Coefficient		Intercept	Multiple Correlation Coefficient R
		Verbal	Reasoning		
2	26	.08	.23	5.28	.52
33	21	.08	.04	3.80	.37
48	29	.30	-.07	7.73	.59
76	15	.22	-.05	4.40	.29
90	21	.07	-.07	6.29	.19
145	25	.21	.06	4.51	.50
154	19	.13	-.02	10.34	.25
155	25	-.07	.08	8.35	.15
156	20	.22	.14	6.30	.38
164	24	-.03	.09	8.24	.11

TABLE 5

Regression Analyses for Ten English Teachers on Microteaching Pretest Lesson 3, June 1967

Teacher	N Ss	Regression Coefficient		Intercept	Multiple Correlation Coefficient R
		Verbal	Reasoning		
3	16	.21	.15	5.35	.53
57	19	.09	.13	7.45	.22
67	18	.31	-.01	6.19	.55
81	22	.18	.23	3.02	.66
95	18	.23	.64	-4.21	.84
114	18	.18	.23	3.93	.63
135	19	.17	.05	8.13	.51
137	19	.11	.26	5.40	.68
157	20	.05	.27	5.26	.42
165	22	.17	.46	2.27	.73

TABLE 6

Regression Analyses for Ten English Teachers on Microteaching Posttest Lesson 4, August 1967

Teacher	N Ss	Regression Coefficient		Intercept	Multiple Correlation Coefficient R
		Verbal	Reasoning		
3	24	.12	.11	10.69	.38
57	20	.17	.15	9.32	.62
66	24	.35	.11	4.02	.64
67	20	.43	-.10	6.04	.42
95	26	.25	.32	3.31	.64
114	23	.18	.27	6.90	.66
135	23	.14	.10	8.20	.55
137	20	.25	-.09	9.00	.45
157	25	.33	-.28	9.55	.39
165	26	.12	.14	9.19	.46

A methodological consideration worth noting for future research involves varying patterns of correlations across classes. As Table 7 shows, aptitude-aptitude correlations vary across classes as do aptitude-achievement correlations. These variations, often slight, affect the multiple regression equations obtained for each sample, since the usual multiple regression procedure extracts first the aptitude variable accounting for the most achievement variance, then the variable accounting for the most remaining achievement variance, and so on. Sampling errors or real differences in aptitude patterns in various classes can result in different orders of aptitude entry in the equations. The common predictable achievement variance would be attributed differently when verbal aptitude accounted for more variance than reasoning aptitude or vice versa. This characteristic of the multiple regression procedure could result in quite different equations and interpretations, even when the various classes exhibited similar aptitude-achievement patterns. One solution is to specify a constant order of entry of aptitude variables in the regression analysis, based perhaps on more stable information from larger groups representing the same subject population. Then teachers could be compared on a common basis and sampling errors in small classes would not unduly affect the order of entry chosen.

Teacher Behavior and Student Aptitude-Achievement Relationships

Another intent of this pilot study was to begin to explore the relationship between teacher behavior and student aptitude-achievement regression slopes. Video recordings of the lessons given by ten of the Social Studies interns included in this study were coded for two teaching skills, reinforcement and probing (see Berliner, 1969). Figures 10 and 11 (see pp. 23-24) were constructed to sketch the possible relationship between student aptitude-achievement slope and teacher behavior for the June and August lessons. For each teacher, two points are plotted: one for the June lesson (circle) and one for the August lesson (triangle). With some exceptions, an increase in the rates of reinforcements and probes and a decrease in the aptitude-achievement regression coefficient seems apparent, going from the June to the August lesson. These changes suggest that the aptitude-achievement correlation decreased over the period of the interns' summer training experience, while teaching skill increased. This finding suggests in turn the hypothesis that greater use of reinforcement or probing skills by a teacher reduces the effect of prior aptitude on student achievement during a specific lesson.

Summary

A pilot study was conducted to investigate the use of regression analysis methods to describe teacher differences as reflected in the aptitude-achievement relationships exhibited by their students. Information collected

TABLE 7

Aptitude-Aptitude and Aptitude-Achievement
Correlation Patterns for Four Lessons

Teacher	Social Studies Lesson 1 (June)			Social Studies Lesson 5 (August)		
	Verbal-Reasoning	Verbal-Achievement	Reasoning-Achievement	Verbal-Reasoning	Verbal-Achievement	Reasoning-Achievement
2	35[a]	62	71	53	37	50
33	---[b]	---	---	64	36	31
48	64	69	72	75	58	39
59	47	45	44	---	---	---
76	---	---	---	-02	28	-09
90	---	---	---	32	11	-11
145	41	49	51	58	49	36
154	58	60	68	50	25	11
155	-03	-05	28	31	-09	09
156	49	29	68	39	34	29
164	---	---	---	57	01	10
	English Lesson 2 (June)			English Lesson 3 (August)		
3	46	48	42	44	34	30
57	11	13	19	35	49	53
66	---	---	---	51	63	44
67	76	55	41	01	39	-13
81	36	57	52	---	---	---
95	50	63	79	32	55	50
114	42	55	50	61	56	62
135	62	51	36	52	52	41
137	19	37	63	31	42	-01
157	33	20	41	63	29	-03
165	41	55	66	59	40	42

[a] Decimals have been ommitted.

[b] A dash indicates absence from teaching sessions.

for the Intern Data Bank was used for these analyses. Preset lessons on topics in English and Social Studies had been taught by Stanford intern teachers to randomly assigned groups of high school students. Achievement information for each student was provided by criterion tests on each lesson. Verbal and reasoning aptitude data had also been collected for all participating students. For each teacher and lesson, regression analyses of student achievement on student aptitude were performed. Teacher differences could then be described by differences in aptitude-achievement relationships exhibited across classes receiving a given lesson: that is, for some teachers, student achievement may be highly related to verbal or reasoning aptitude, whereas for others, student achievement and student aptitude variables may be relatively independent of one another. A test or the heterogeneity of regression slopes was used for statistical comparisons. Both simple and multiple regression analyses were performed, using first one and then both aptitudes as independent variables.

No examples of significant heterogeneity of regression slopes or planes were found in the sample sets of data examined. Methodological problems caused by differences in aptitude among the various groups of students were noted. Possible correlations between teacher behavior and student aptitude-achievement relationships were briefly explored.

The present study, being severely limited by sampling and methodological restrictions, provides no bases for conclusions. Its purpose was merely to explore the idea that student aptitude-achievement relationships might index important features of teacher effectiveness. Further research is needed to investigate the relationship between teacher behavior and student aptitude-achievement patterns in more detail and to examine the effects on such patterns of grade and subject matter, of teacher training and experience, and of the aptitude and achievement variables used.

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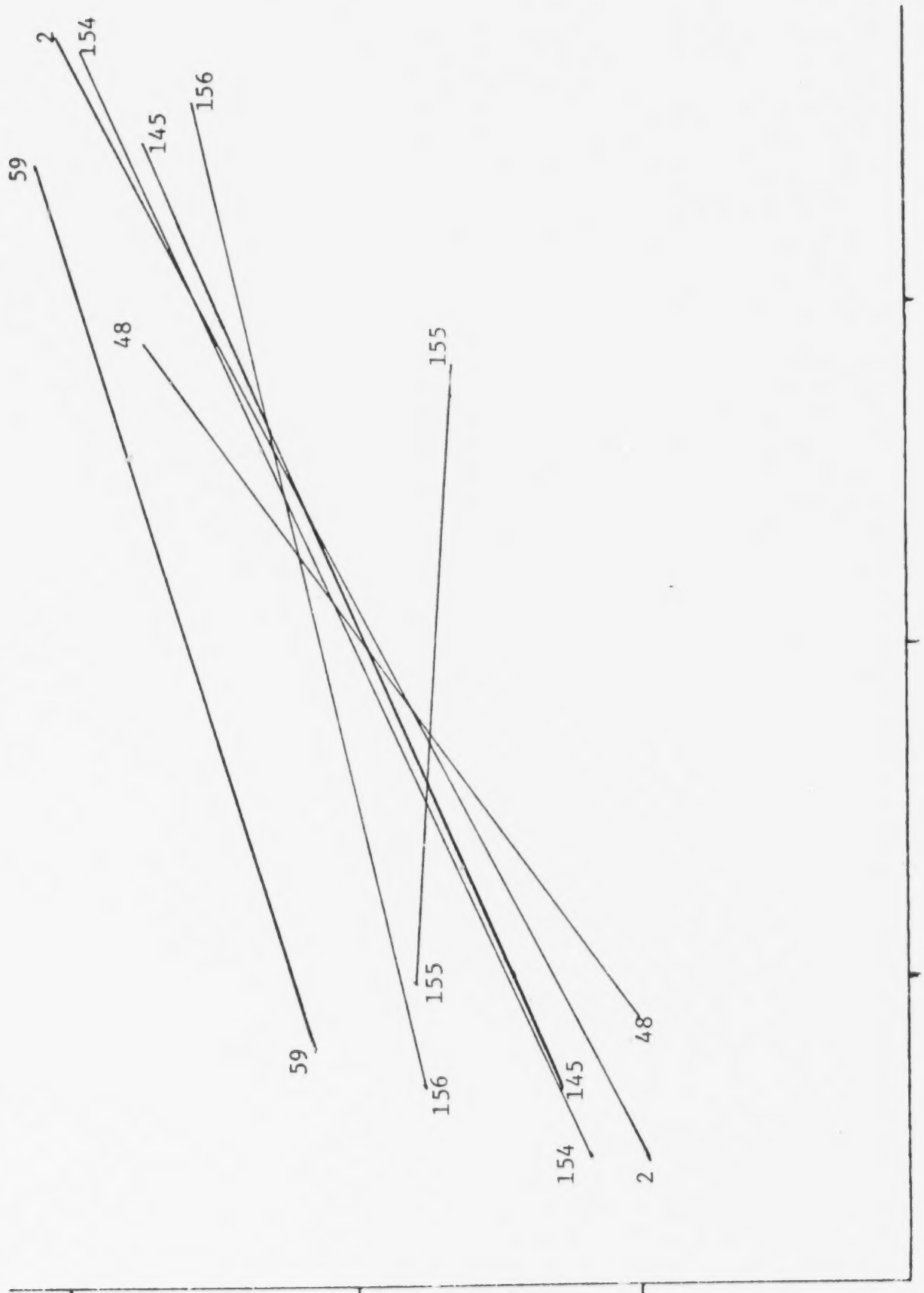


Fig. 1. Social Studies Lesson 1: Regression of Achievement on Verbal Aptitude for Seven Teachers.

Fig. 2. Social Studies Lesson 5: Regression of Achievement on Verbal Aptitude for Ten Teachers.

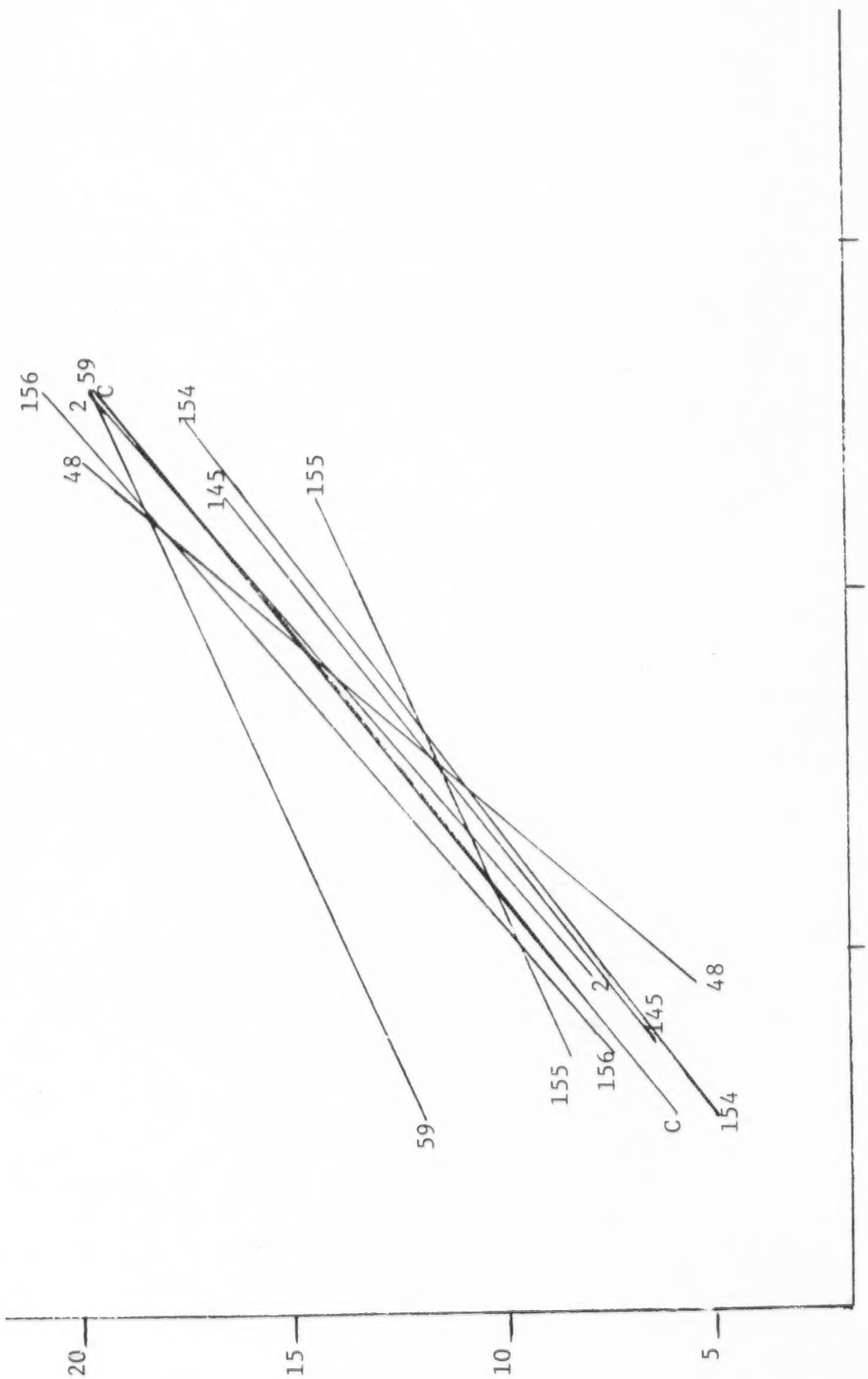


Fig. 3. Social Studies Lesson 1: Regression of Achievement on Reasoning Aptitude for Seven Teachers.

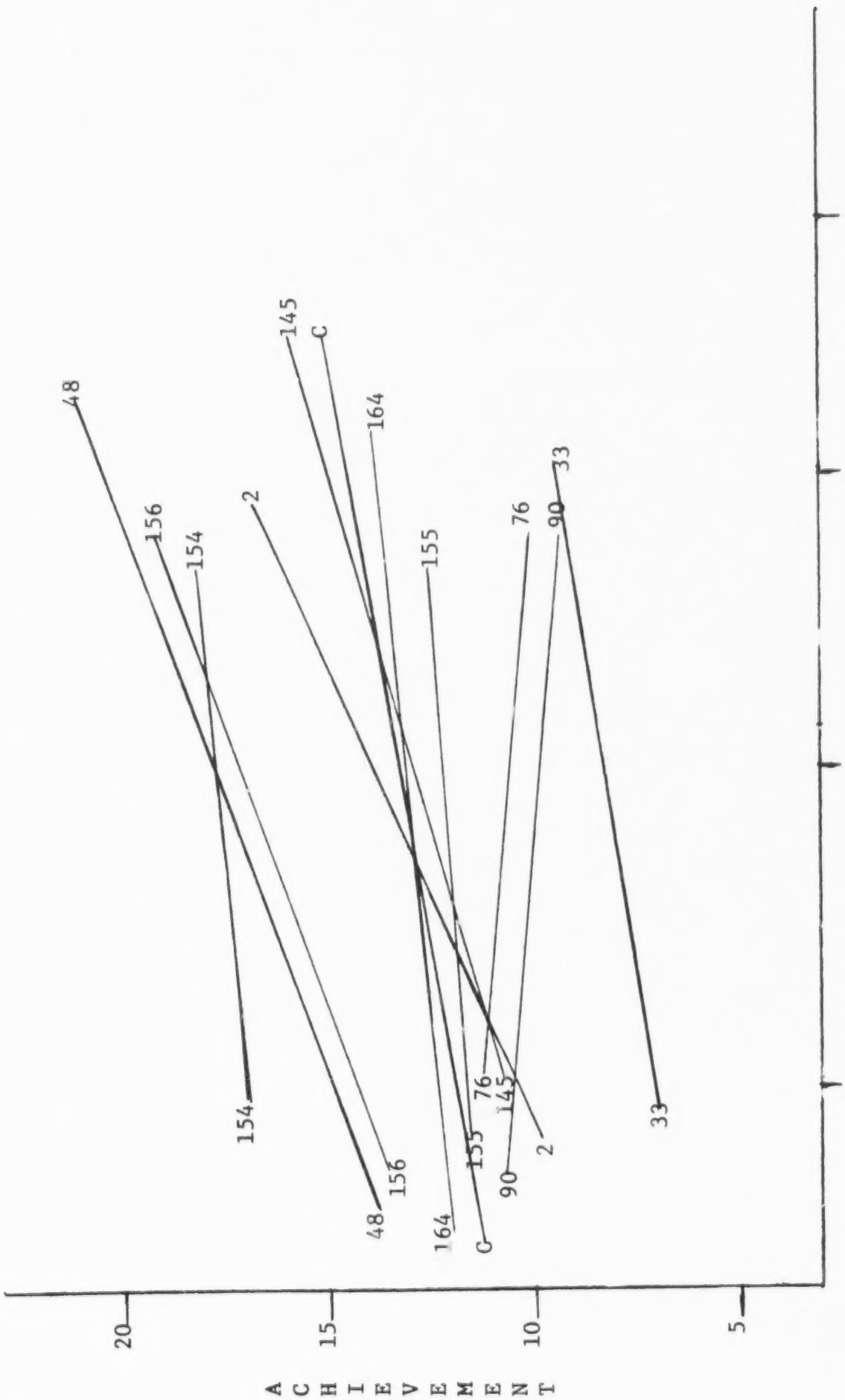


Fig. 4. Social Studies Lesson 5: Regression of Achievement on Reasoning Aptitude for Ten Teachers.

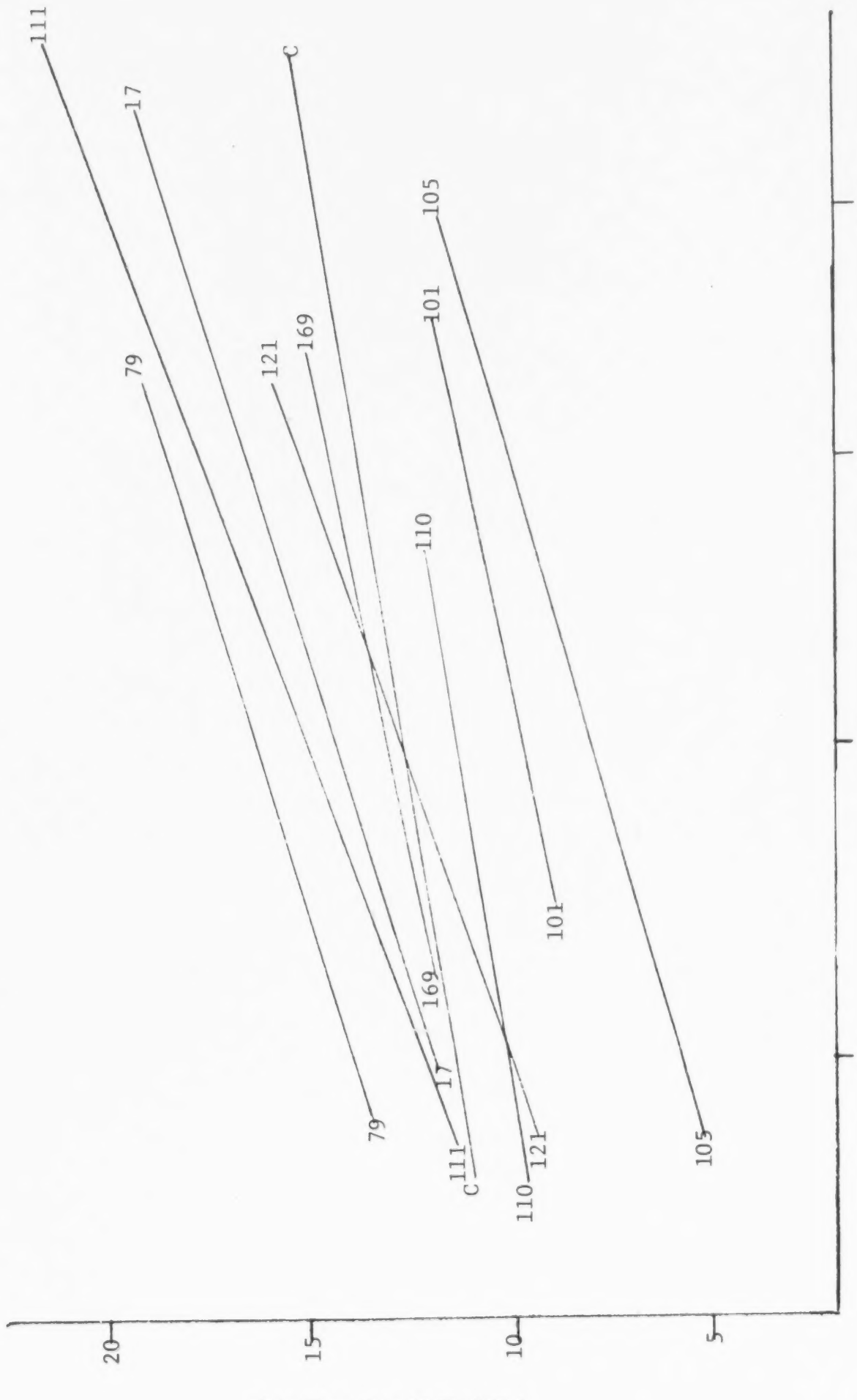


Fig. 5. Social Studies Lesson 2: Regression of Achievement on Verbal Aptitude for Eight Teachers.

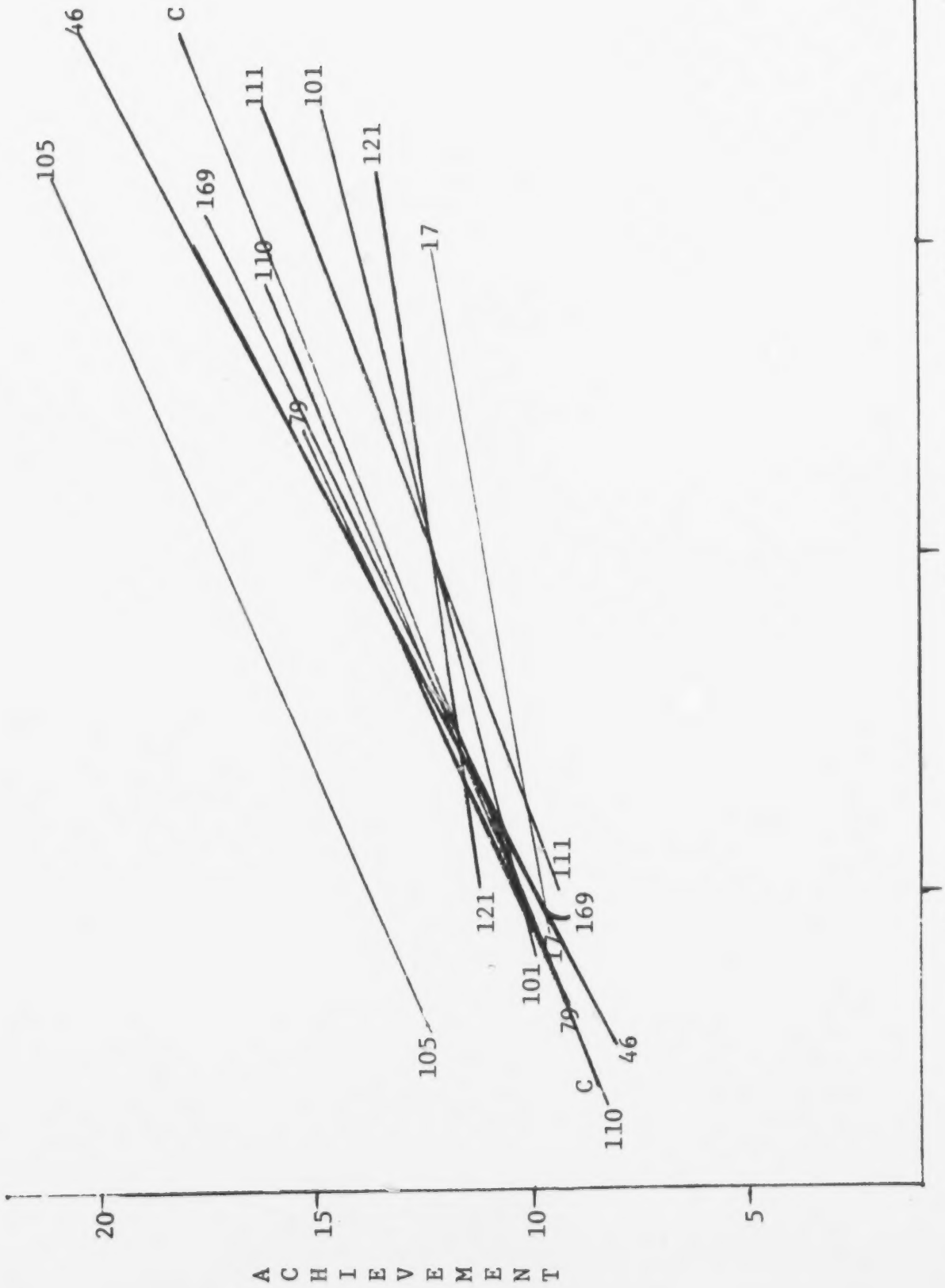


Fig. 6. Social Studies Lesson 6: Regression of Achievement on Verbal Aptitude for Nine Teachers.

Fig. 7. Social Studies Lesson 2: Regression of Achievement on Reasoning Aptitude for Eight Teachers.

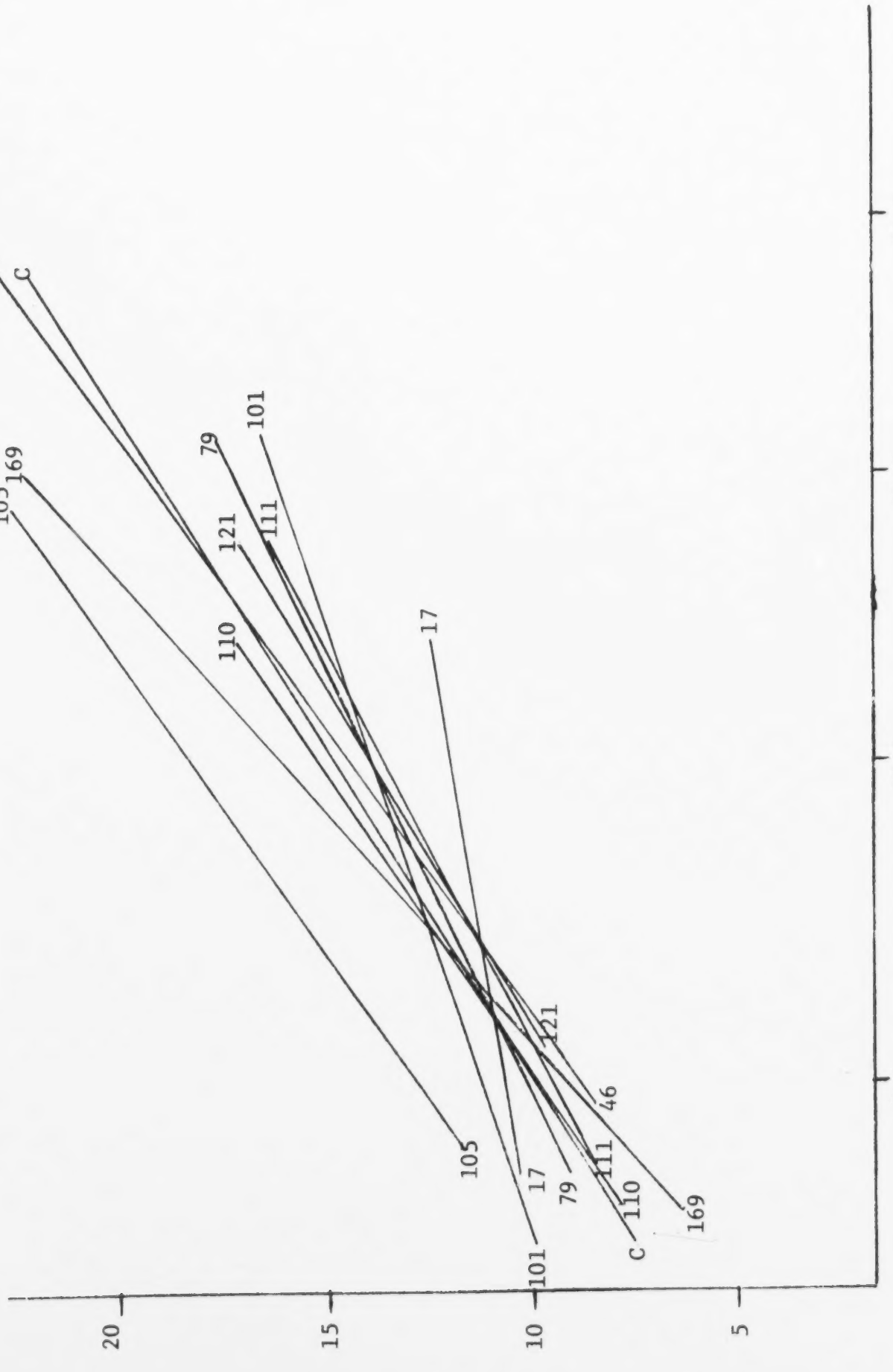


Fig. 8. Social Studies Lesson 6: Regression of Achievement on Reasoning Aptitude for Nine Teachers.

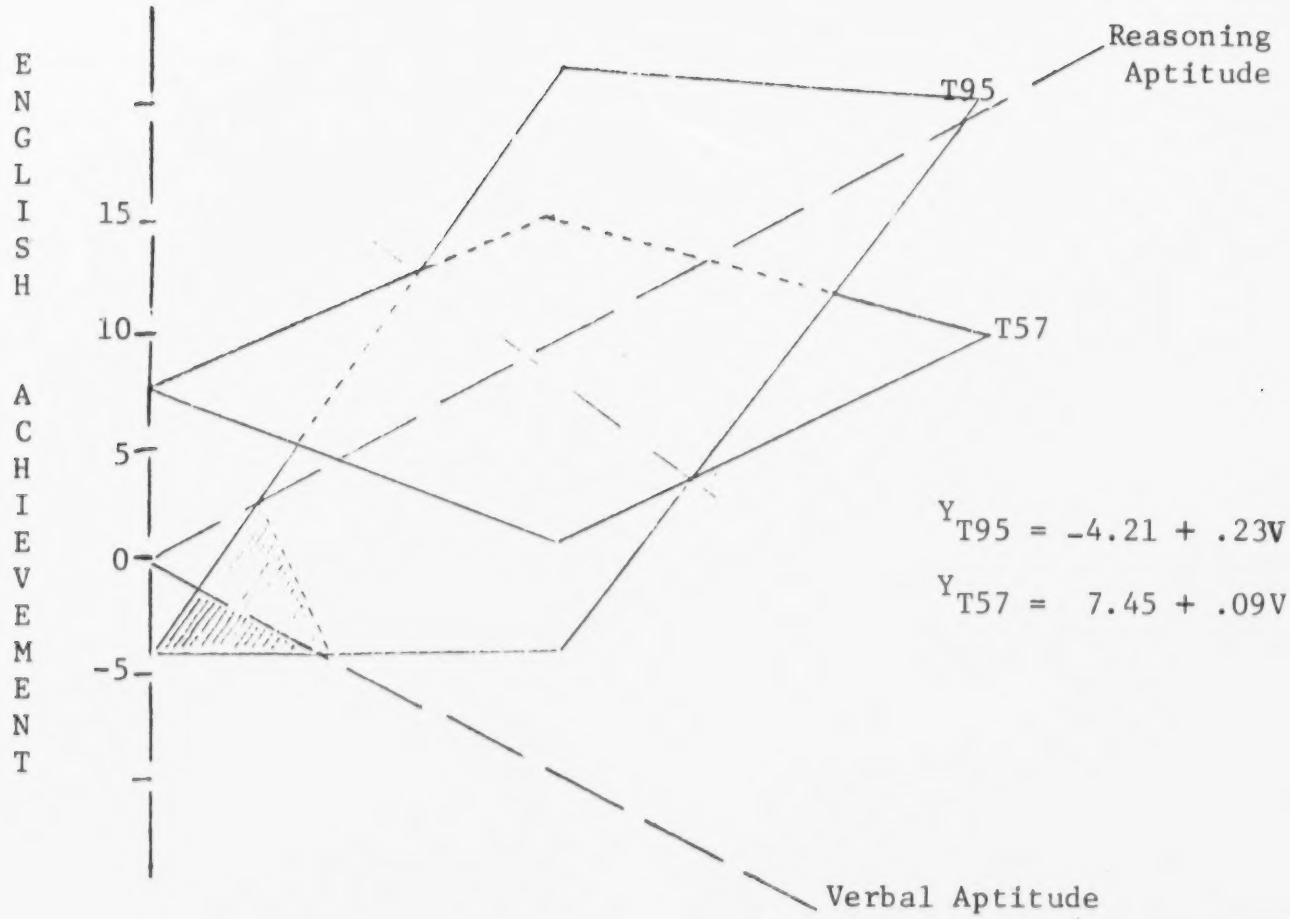
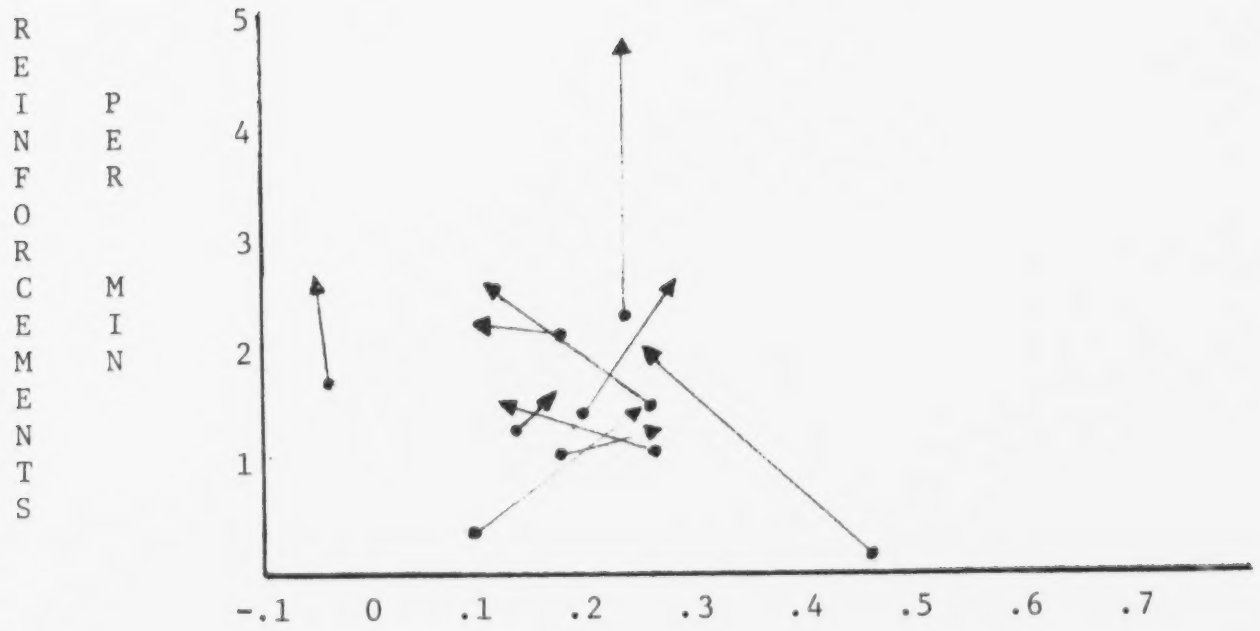


Fig. 9. Bivariate Regression Planes Showing the Relation of Aptitudes and Achievement for Two Teachers.



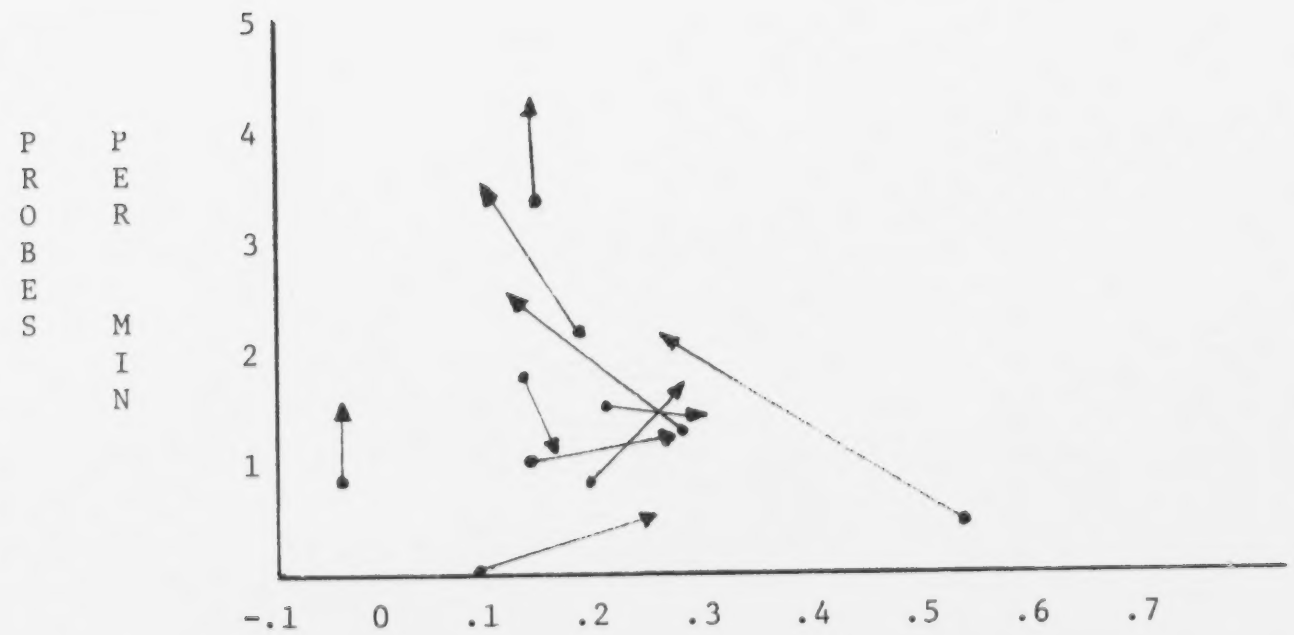
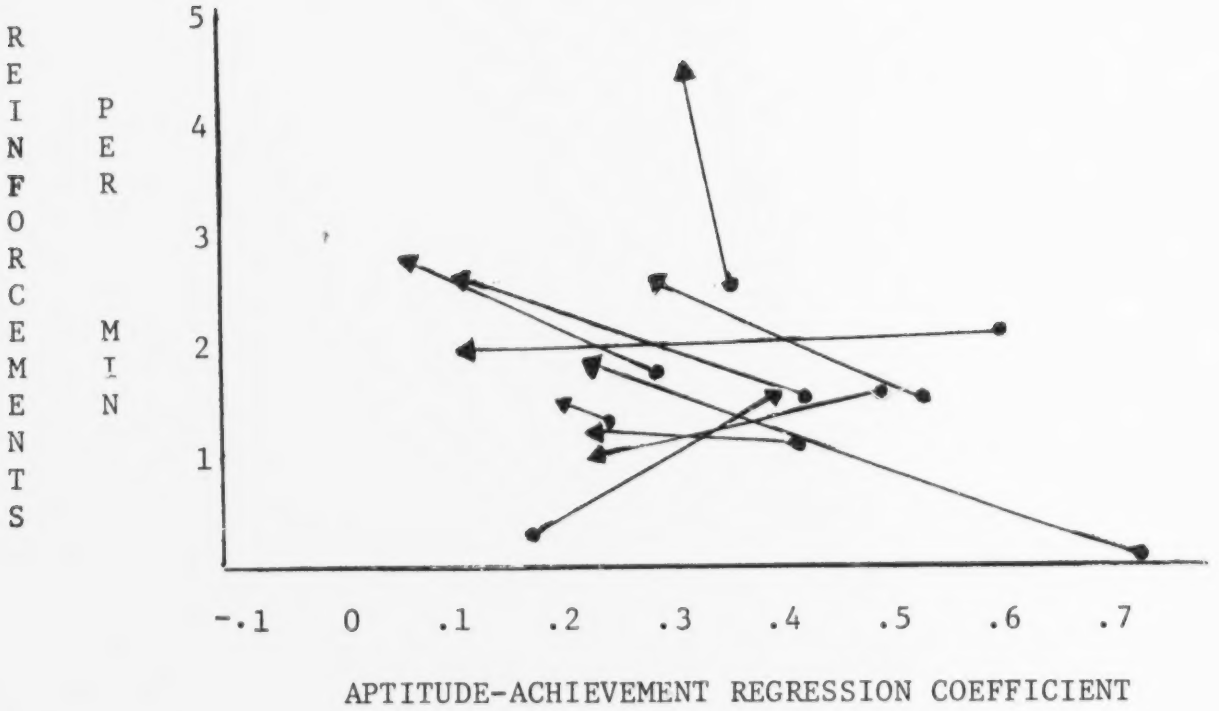


Fig. 10. Change in verbal aptitude-achievement regression coefficient from June (•) to August (▲) related to rate of reinforcements and rate of probes.



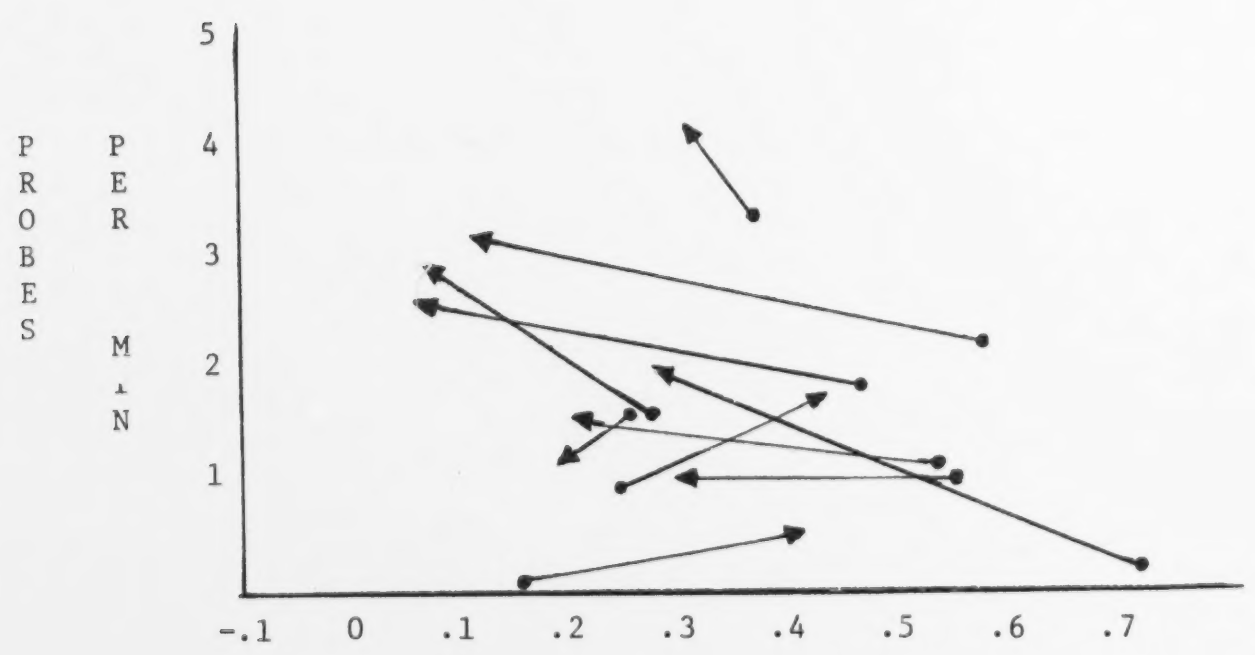


Fig. 11. Change in reasoning aptitude-achievement regression coefficient from June (•) to August (▲) related to rate of reinforcements and rate of probes.